THE ROYAL SOCIETY

doi 10.1098/rstb.2001.0940

Sensory-perceptual episodic memory and its context: autobiographical memory

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Episodic memory is reconceived as a memory system that retains highly detailed sensory perceptual knowledge of recent experience over retention intervals measured in minutes and hours. Episodic knowledge has yet to be integrated with the autobiographical memory knowledge base and so takes as its context or referent the immediate past of the experiencing self (or the 'I'). When recalled it can be accessed independently of content and is recollectively experienced. Autobiographical memory, in contrast, retains knowledge over retention intervals measured in weeks, months, years, decades and across the life span. Autobiographical knowledge represents the experienced self (or the 'me'), is always accessed by its content and, when accessed, does not necessarily give rise to recollective experience. Instead, recollective experience occurs when autobiographical knowledge retains access to associated episodic memories. In this reworking of the 'episodic memory' concept autobiographical memory provides the instantiating context for sensory-perceptual episodic memory.

Keywords: autobiographical; knowledge; representation; retrieval; recollection

1. SENSORY-PERCEPTUAL EPISODIC MEMORY AND ITS CONTEXT: AUTOBIOGRAPHICAL MEMORY

Over the past decade our research into autobiographical memory has led us to an account of human memory in which personal goals play a major role in the formation, access and construction of specific memories (Conway & Pleydell-Pearce 2000). A central tenet of this account is that a fundamental function of human memory is to retain knowledge on the progress of personal goals, i.e. whether they have been achieved or not. Goals are considered to be represented in complex goal hierarchies where they form a part of the 'working self'. Because goals in a hierarchy will vary in how near or distant they are from attainment, a wide range of different types of knowledge are required to make accurate assessments of goal attainment progress. For example, successful completion of the goal of 'taking a coffee break' may be part of the goal hierarchy 'to write a paper', which in turn is part of a wider hierarchy of goals that collectively aim to reduce discrepancies between parts of the self and satisfy broad sets of motives. Recalling the coffee break provides evidence that the goal was achieved and, perhaps, reminds the rememberer that a larger goal has not been achieved. Of course, once the paper has been written, recalling, for example, putting it in the mail, is itself 'evidence' of goal attainment. Episodic information, because it is frequently of actual experience (is 'experience-near') has a special status as evidence that goals have been achieved, have not been achieved, have been modified, changed or abandoned.

The term 'episodic information' refers to knowledge contained in episodic memories and this is conceived as being very largely sensory-perceptual in nature. Such experience-near sensory-perceptual knowledge, when accessed during remembering, supports 'recollective experience' and, consequently, episodic memory has a unique affinity for this type of memory awareness (Wheeler *et al*. 1997). Recollective experience is the sense or experience of the self in the past and is induced by images, feelings and other memory details that come to mind during remembering— see Gardiner & Richardson-Klavehn (1999) and Gardiner (this issue) for reviews. In our approach this memory awareness or feeling state (the sense of the self in the past) signals to a rememberer that the mental representation it is associated with is in fact a memory of an experience that actually occurred and is not a fantasy, dream, plan or some other (experience-distant) mental construction. Thus, recollective experience effectively says 'this mental representation is a memory of an event experienced by the self'. Note that it does not follow from this that recollective experience always indicates a true memory—'true' in the sense that the recalled experienced actually occurred—but when recollection is present the probability is high that the remembered event was one that had been previously experienced (see Conway *et al*. 1996; Roediger & McDermott 1995).

These considerations lead us to a revision of the 'episodic memory' concept as this was originally proposed by Tulving (1972) and later elaborated (Tulving 1983, 1985; Wheeler *et al*. 1997). We conceive of episodic memory as a system that contains experience-near, highly event specific, sensory-perceptual details of recent experiences—experiences that lasted for comparatively short periods of time (minutes and hours). These sensory-perceptual episodic memories do not endure in memory unless they become linked to more permanent

Table 1. Characteristics of sensory-perceptual episodic memory.

- Retains records of sensory-perceptual processing derived from working memory
- Contains organizing abstract knowledge derived from goals active during experience
- Represents short time slices, possibly determined by changes in goal-processing
- Represented roughly in the order in which they occurred
- Has a short duration (measured in hours)
- If they become integrated with AM, access becomes stable and durable
- They are recollectively experienced when accessed
- When included as part of an AM construction they provide specificity
- Neuroanatomically they may be represented in brain regions separate from other AM knowledge
- They may have a distinctive form of organization
- They may have EM-unique retrieval process in addition to more general access processes

autobiographical memory knowledge structures, where they induce recollective experience in autobiographical remembering. By this view access to episodic memories (EMs) rapidly degrades and most are lost within 24 h of formation. Only those EMs integrated at the time or consolidated later, possibly during the sleep period following formation, remain accessible and can enter into the subsequent formation of autobiographical memories (AMs).

We have further concluded that EMs are represented in the brain regions most closely involved in the processing that took place during actual experience. Because of this, EM sensory-perceptual details are represented in posterior regions of the brain and especially in networks sited in the occipital lobes, posterior parts of the temporal lobes, and (conceivably) in posterior parietal lobes. Other more conceptual and abstract, experience-distant, autobiographical knowledge may be represented in networks with a more anterior location. Thus, it is proposed that EM is, in terms of neuroanatomy, a topographically separate memory system. Table 1 summarizes the main points of our revised conception of EM (for more detailed accounts see Conway 1992, 1996; Conway & Pleydell-Pearce 2000).

According to the present view, EMs represent knowledge of specific actions and action outcomes derived from moment-by-moment experience—the minutiae of memory. Although this is specific evidence on the progress of immediate and recent plans, it cannot on its own be used to evaluate more complex goals in working-self goal hierarchies. Instead, the organization of groups of episodic memories and abstractions drawn from them, along with attitudes and beliefs of the working self, form conceptual autobiographical knowledge. Such conceptual autobiographical knowledge is a major part of AM where it contextualizes and 'frames' EMs while simultaneously providing higher order evidence of goal completion, suspension, revision or abandonment. Autobiographical memory is, then, a type of memory that persists over weeks, months, years, decades and lifetimes, and it retains knowledge (of the self) at different levels of abstraction. In what follows AM is considered first, followed by EM and contrasts between the two.

2. AUTOBIOGRAPHICAL MEMORY

An AM is a transitory mental representation: it is a temporary but stable pattern of activation across the indices of the AM knowledge base that encompasses knowledge at different levels of abstraction, including event-specific sensory perceptual details (EMS), very often—although by no mean always—in the form of visual mental images. This sort of memory has various functions, characteristic knowledge types, modes of access, supports certain phenomenological experiences, and is associated with certain brain areas, as will now be considered in turn.

(a) *Functions*

As might be expected of a complex higher order form of cognition, AM serves many functions. The particular function we have highlighted in our approach is that of grounding the self. By this we mean that memories, and autobiographical knowledge more widely, place constraints on what goals the self can realistically maintain and pursue. A corollary of this is that memory and the self strive to be congruent. The working self makes preferentially available memories and knowledge that are congruent with the goals of the self (for a review of the extensive evidence demonstrating this, see Conway & Pleydell-Pearce 2000; for an earlier account, see Greenwald 1980). Indeed, so overriding is the need for memory–self congruency that aspects of the self (attitudes and beliefs) may change to fit initially incongruent autobiographical knowledge (see Ross 1989) or memories themselves may be altered, misremembered, or inhibited in order to preserve the self from change. Memories are encoded in terms of the self (cf. Hastorf & Cantril 1952 for an early, and still one of the best, studies of this) and experiences with strong self reference may receive privileged encoding that render them highly accessible and capable of evoking intense experiences of recollection, i.e. vivid and flash bulb memories (for a review, see Conway 1995).

The importance of congruency can be seen in a variety of illnesses when the self and memory become split and no longer constrain one and other. Delusional beliefs, for example, derive their pathological status in part from the fact that they are fantastic for the individual who holds them. Thus, the deluded schizophrenics interviewed by Baddeley *et al*. (1996) all had (deluded) beliefs that were either not supported or that were contradicted by accessible autobiographical memories. On the other hand, they all also described 'memories' (usually of implausible events, e.g. having most of their brain removed by a bad angel, etc.) that in some often obscure respects were consistent with their delusions and even supported them. It seems clear that in this sample of patients at least, memory no longer grounds the self in the sense that it places constraints on what the self can be. A similar split, disruption, or attenuation may occur in neurological patients who suffer damage to the frontal lobes and subsequently confabulate. In the case of plausible confabulations the false memories are constructed from autobiographical knowledge but configured in ways that depict events that did not occur—they are in Moscovitch's (1989) memorable phrase 'honest lies'. Such configurations may not be random but instead reflect the operation of a

damaged working self generating memories with (in most cases) an impaired goal system. Motivated confabulations may support the fabrication of a past that serves a function in the present. Thus, the confabulated memories of extensive family support by a frontal patient living through a time of illness and loneliness provide a source of support (Conway & Tacchi 1996), just as the confabulated memories of arranging business meetings by another frontal patient provided him with a sense of continuing at his former level of professional functioning (Burgess & McNeil 1999).

The integrity of the self and autobiographical knowledge is then, critical for a normally functioning system and this is because AM is the knowledge base of the self. Once the connection becomes impaired in some way, either neurologically or psychologically, then autobiographical knowledge, which may remain accessible, no longer constrains the goals of the working self and delusions and confabulations then occur. This grounding or constraining function also has another aspect in that it provides the self with continuity and stability. Knowledge of goal attainment contained in AMs and autobiographical knowledge generally can be a positive resource of the self (even if plausibly confabulated) during times of stress (Robinson 1986). On the other hand it can be negative, as a constant reminder of failure, and so may be defended against as in patients with clinical levels of depression who recall many 'over-general' memories (Williams 1996). Autobiographical knowledge then functions to ground the self in memories of actual experiences or in remembered reality (which does not always, even though it may usually, correspond to actual reality).

(b) *Knowledge*

We have identified three basic types of autobiographical knowledge that vary in their conceptual specificity, ranging from the abstract and generic to the sensory perceptual and event specific, as well as in their temporal specificity, denoting periods measured in decades and years to periods covering minutes and hours (see Conway & Pleydell-Pearce 2000; Conway & Fthenaki 2000). 'Lifetime periods' are the most abstract and temporally extended AM knowledge structures. They contain knowledge about others, activities locations, feelings and evaluations common to a period as a whole. A period such as 'when I was at secondary/high school' might contain generic images of teachers, classrooms, sports hall, thoughts about particular class topics, e.g. English, Maths, etc., as well as evaluations about what the person was good/bad at, their likes and dislikes, what was achieved academically and otherwise, and what changes mark the start and completion of the period. A lifetime period may also contain a more or less detailed evaluation, e.g.'this was a good/bad time for me' and they may be chunked into higher order units to form life story schema which in turn form part of the self concept (see Bluck & Habermas 2001). Lifetime periods are thus abstract mental models of the self during a delineated period of time usually defined by a theme or common set of themes, e.g. school, work, relationships, etc.

Lifetime period knowledge can be used to access other more specific knowledge and in particular representations of what we have termed 'general events'. The level of general events is the preferred level of processing in AM and optimizes the amount of specific information available for least cognitive effort (see Rosch 1978). It is worth noting that accessing autobiographical knowledge is effortful. For instance, generating a specific memory captures attention and averages, under laboratory conditions, 5 to 7 s with few retrieval times less than 2 s. Therefore, a basic level at which cognitive effort is reduced and access maximized provides a relatively non-demanding point of entry into this complex knowledge base. General events are more experience-near than lifetime periods and contain information about others, activities, locations, feelings and evaluations relating to specific experiences. These experiences might be of repeated events, e.g. 'walks in the fields' (see Barsalou 1988), extended events, e.g. 'our holiday in Italy', or they may be more specific, e.g. 'the interview', 'day trip to London' and so on. Furthermore, there may be local organization in general events leading to the formation of 'mini-histories' (Robinson 1992) such as learning to drive a car, learning to use the library, romantic first relationship, making friends with X, etc. Mini-histories may have very direct connections (one-to-one mappings in cues) to an associated lifetime period, e.g.'when I was at secondary/high school'. General events are, then, heterogeneous and contain information that can be used as cues to access lifetime periods or sensory perceptual EMs. It is these latter knowledge structures that form the third level of autobiographical knowledge and they are considered in detail in § 3 below, although it might be noted here that when an EM or set of EMs are included as an active part of a constructed memory they always evoke recollective experience (the sense of the self in the past).

(c) *Access*

Autobiographical memories are patterns of activation over the indices of AM knowledge structures and typically consist of a general event plus one or more EMs. Lifetime period structures are not always active, as the same lifetime period may access many general events and, once a search of general events is initiated, local organization at this level may make access of the lifetime period redundant in subsequent searches of the same region of the knowledge base. Indeed, when the system is in retrieval mode, i.e. there is a conscious intention to retrieve memories, then searches at the level of general events may be preferred. Conway & Pleydell-Pearce (2000) review a large body of findings, demonstrating that two types of cue-driven retrieval processes mediate access to the data base and memory construction—direct and generative retrieval.

In general, it is proposed that the AM knowledge base is highly sensitive to cues. These can be externally presented or internally generated and their effect is to automatically cause patterns of activation to constantly arise and dissipate within the knowledge base. These endogenous patterns of activation, the result of encoding specificity (Tulving & Thompson 1973), do not usually stabilize into representations that could become memories nor do they attain a threshold that can capture attention. The reason for this is that most cues activate knowledge

in general events and lifetime periods. Undirected activation spreading from lifetime period knowledge weakly activates many general events and therefore rapidly dissipates. Similarly, activation automatically spreading from a general event weakly activates a single or (rarely) multiple lifetime periods, associated general events and a pool of sensory-perceptual EMs. Again, this uncontrolled spread of activation to associated structures quickly weakens and fades. Direct access only occurs when a cue maps on to and, consequently, highly activates EM (either a single or set of EMs) and activation spreads from here to a single general event and to an associated lifetime period. Automatic activation of EM by an endogenous cue is, however, a comparatively rare occurrence because the cue would have to closely correspond to the sensory-perceptual content of an EM and the probability of processing some item in a way highly similar in content to an existing EM is low (Conway & Pleydell-Pearce 2000; see also Conway, 1992, 1996, 2001). Although the probability is low, given the constant effect of cues on the knowledge base, it must be the case that direct access leads to the formation of patterns of activation that can become memories on at least some occasions. The final step in memory formation is for the (stable) pattern of activation to become linked to the goal structure of the working self and enter consciousness. It seems that even at this stage a memory may not be formed, especially if this will disrupt current processing sequences that are prioritized. Nevertheless, recent data indicates that people experience the sort of 'spontaneous' retrieval that direct access can give rise to at a rate of two to three memories on average per day (Berntsen 1996). Moreover, in pathological conditions such as post-traumatic stress disorder intrusive involuntary recall triggered by cues that correspond to event specific knowledge (ESK) is a major symptom of the disorder (for a recent review, see Brewin 1998). In this case the intrusion or spontaneous recall rate can be at chronically high levels, especially in the early post-trauma period.

Recalling autobiographical memories is often an intentional act in which the rememberer enters 'retrieval mode' and actively searches for particular types of knowledge in order to construct or generate a memory. Convergent evidence points to a complex generative retrieval process in which cues are first elaborated, memory searched (an automatic part of the cycle), the outputs from memory are then evaluated and, if required, these are then elaborated further and another search undertaken. In this way a specific memory (a pattern of activation in the knowledge base) is iteratively constructed. For example, consider a participant in an AM cue-word experiment whose task is to recall specific memories to cues presented by the experimenter (a common procedure in this area) and the word 'chair' is presented. A typical initial elaboration is to map the cue onto one's current environment and perhaps the participant thinks of 'the chair in the hallway at home'. The next elaboration might be to generate a template for a specific event in which this object once featured and the cue might then be refined into 'when did we buy it'? This may lead to access of lifetime period knowledge e.g. 'that was when we lived in city X in the house at Y'. Recycling this information in a further search produces 'saw it in a sale at store W', followed by access of EMs and a flood of event-specific details in the form of visual images. This latter point in retrieval is highly characteristic of the endpoint of memory construction (at least when studied in the laboratory, cf. Conway 1996). Conway & Pleydell-Pearce (2000) describe how generative retrieval is controlled by a 'retrieval model', used to verify and elaborate memory output, that in turn is generated by the working self and derived from the currently active goal structure. Despite the slow construction times seen in the laboratory in extended intentional memory construction, in everyday life when cues in the environment, e.g. in interaction with family members, friends, colleagues, etc., are more potent and when the knowledge base has been repeatedly sampled, raising the activation levels of relevant autobiographical knowledge generally, memory construction will then be facilitated and access will occur much more rapidly—see Crovitz (1986) for a powerful demonstration of this with a post-traumatic amnesic patient, and see Conway & Bekerian (1987) for evidence that cues which map on to individual autobiographical knowledge can produce average retrieval times of about 2 s, which is nearly twice as fast as mean retrieval times in cue-word experiments.

(d) *Phenomenology*

Much goal-centred processing takes place outside awareness and this is especially true of the autobiographical knowledge base in which patterns of activation constantly arise and dissipate without becoming conscious. This, however, serves to sharpen the question of why memories enter into consciousness given that access to the knowledge base can be non-conscious. We believe that one function of consciousness is to facilitate decision making and plan formulation by enabling the ability to choose. Thus, conscious awareness allows intentional choice among alternative courses of action with different goals. Because memories carry information about goal attainment they are particularly useful in goal-appraisal, change and formation, which will inevitably feature conscious intentional choices (for a related view, see Schank 1982). Note that information about goal attainment does not have to be explicit in a memory. Rather autobiographical knowledge and the mental representations to which it is able to give rise can be conceived as being the output or expression of the goal system at a previous point in the past. It is the content of the knowledge—what it makes plausible and what it makes implausible for the self—and its configuration that carries the goal attainment knowledge. Goal attainment autobiographical knowledge is therefore important in these decision making processes because it carries information about the outcomes of previous choices and plans—hence, perhaps, the inter-relatedness of memory, self and consciousness.

One of the main ways that this inter-relatedness may occur in remembering is through the special mental state known as 'retrieval mode' (Tulving 1983). Little research had been specifically directed at this but nonetheless some points can be made. Retrieval mode is characterized by a turning inwards of attention, a redirecting of attention from action to mental representations and, as a consequence, can probably only be engaged in under certain

circumstances, i.e. those that place a low demand on conscious decision making (Conway 2001). Retrieval mode is also a state in which the cognitive system is prepared for or expects memory construction and recollection, i.e. networks are dysfacilitated or decoupled from other processing sequences in which they currently run and reassembled into interlocked networks primed for memory generation (cf. Damasio 1989, and see Lepage *et al*. 2000 for a recent neuroimaging study). One aim of retrieval mode might be to facilitate the occurrence of recollective experience when the 'me' self (the autobiographical self) is experienced as the 'I' (the working self). Thus, recollective experience might be thought of as a feeling state that arises when the working or experiencing self initiates retrieval mode and constructs a specific memory containing, among other knowledge types, sensory perceptual ESK, and in this way 'experiences' the past. A function of recollective experience itself might be to signal that the currently attended mental representation is a representation of the self in the past, the 'me', and not some other type of representation such as a daydream, fantasy or rumination. In enabling the subjective experience of the past, the recollective feeling state indicates that potentially useful goal attainment knowledge is currently available.

Although the endpoint and, perhaps, the main aim of retrieval mode is recollective experience and the phenomenological experiences associated with it, another feeling state is also possible—that of feelings of knowing (Tulving 1985). Feelings of knowing arise when conceptual, generic or abstract knowledge is activated (Conway *et al*. 1997) and this must occur during the course of AM construction too, when generic autobiographical knowledge in lifetime periods and general events is accessed. Rememberers 'just know' they attended a specific school, had a particular job, lived with a certain person, and so on. A possibility here is that the 'knowing' or 'just knowing' feeling state is one that, in terms of cognitive effort, is less costly than recollective experience and although it may occur when the system is in retrieval mode as specific memories are constructed, it can also occur in other states that do not feature retrieval mode.

Finally, in this section very recent work is considered showing that rememberers have cognitive reactions to their memories and these reactions relate to the perceived consistency of memories. Beike & Landoll (2000) found that when a memory was recalled from a lifetime period, but the recalled event was inconsistent with the lifetime period, various reactions followed. For a memory of an event judged to be a good, or positive experience drawn from a lifetime period judged as negative, the dissonant memory might be set against the many negative memories available from the lifetime period and in this way outweighed. Alternatively, rememberers provided justifications for the remembered experience, some unique reason why it was inconsistent, i.e. 'it was a fluke', 'it happened by chance', and so on. The important point is that constructing an AM not only features characteristic forms of conscious experience but also can cause other reactions and feelings relating to current goals of the self and to the requirement that the self and memory should be congruent.

(e) *Neurology*

There is a large clinical literature, mainly on case studies of impairments of AM, demonstrating that this type of remembering can be disrupted by impairments to many different brain regions including networks in frontal, temporal and occipital lobes as well to midbrain structures in hippocampus, amygdala, fornix, and thalamus (for a review, see Conway & Fthenaki 2000). Given the complexity of AM and its role in the self and consciousness, wide distribution of the processes that mediate it is only to be expected. Here we will focus on a recent electroencephalography (EEG) study from our laboratory that mapped changes in slow cortical potentials (SCPs) detected from electrodes on the scalp during autobiographical remembering (Conway *et al*. 2001*a*) and which provides a good summary of the neurological complexity of autobiographical remembering. Changes in SCPs were monitored while participants: prepared to recall memories (pre-retrieval phase); recalled memories to cue words (retrieval phase); made a manual response to indicate when they had a detailed and specific memory in mind; and then held the memory in mind for several seconds (hold memory in mind phase). Head plots of patterns of activation taken from one second epochs early, middle and late, in the three phases and baselined to a point in the inter-trial interval are shown in figure 1. Note that the head plots are statistical extrapolations from activity detected by individual electrodes placed in a international 10–20 system. The top of each plot represents the front part of the brain, the left and right sides of each plot correspond to left and right cortical hemispheres, red shading indicates regions in which negativity (activation) was detected and blue shading indicates areas of positivity (dysfacilitation). The leftmost plot in each row is taken from an early point in that phase, the middle plot from a midpoint, and the right-hand plot from a period close to the end of the phase.

The head plots in figure 1*a* show the pattern of activation detected in the pre-retrieval phase after the start of a trial has been signalled and while participants focus on a fixation point and await the presentation of the (next) cue word. Early in this phase bilateral prefrontal activation is present but, as the phase proceeds, activation spreads and, most notably, the anterior part of the left temporal lobe becomes highly active, especially so just before presentation of the cue. One possibility is that this activation reflects pre-retrieval priming of networks in the frontal lobes and left anterior temporal lobe that will mediate generative retrieval once that is initiated by presentation of the cue. More generally, this might reflect the system entering retrieval mode in preparation for memory construction (see Lepage *et al*. 2000).

Figure 1*b* shows that once retrieval starts negativity rises sharply in the frontal lobes and the source of this emanates from networks in the left prefrontal cortex. As the retrieval period proceeds, activation starts to build in posterior sites (middle and right side head plots in figure 1*b*), sites which had previously been strongly positive or dysfacilitated. Once a memory is formed this pattern of left frontal activation linked to mainly right posterior temporal and occipital activation is temporarily lost (left head plot of figure 1*c*). This period just after memory formation is particularly interesting because after

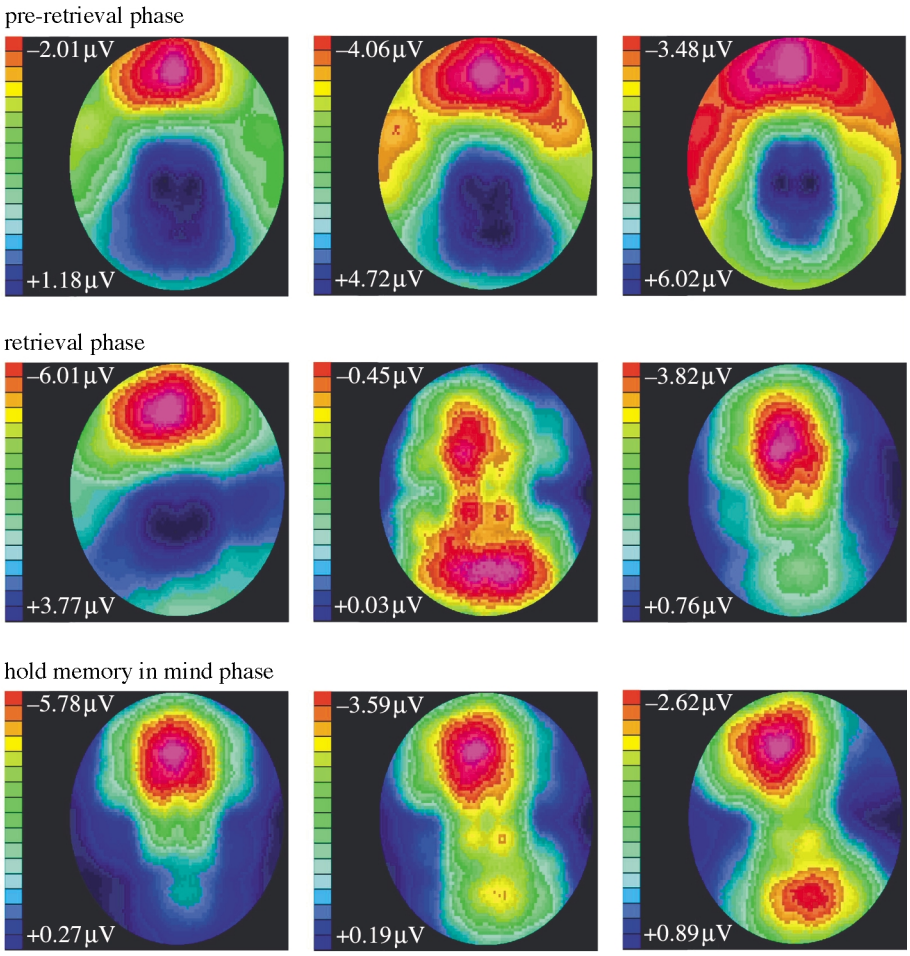

Figure 1. Topographic representations of the distribution of surface negativity during (*a*) pre-retrieval, (*b*) retrieval and (*c*) the 'hold memory in mind' phase. The plots employ a separate minimum–maximum scale determined by the most negative and positive electrodes in that phase. This is in order to optimize visual comparison between electrodes within each phase.

participants made a (manual) response, to indicate that a memory was in mind, we detected a very strong negative wave bilaterally and centrally placed in the frontal lobes. This component was found to be unrelated to motor activity and may be what we have termed a memory engagement potential (MEP). The MEP occurs as frontal networks reconnect, following co-ordinating the motor response with the recently formed memory and, while the fully formed memory is held in mind, activation is then detected in the left frontal lobes, right posterior temporal lobes and bilaterally (stronger on the right than left) in the occipital lobes.

These neurophysiological findings fit well with other studies that have also detected posterior activation in episodic remembering (Nyberg *et al*. 2000; Wheeler *et al*. 2000; see also Markowitsch 1998) and collectively they suggest that EMs may be represented in those sensory-perceptual regions of the brain involved in their original processing. AM is, however, more than just a record of sensory-perceptual processing, and the pattern of activation unfolding over the whole period and culminating in an interlocked pattern of frontal and posterior activation once a memory is formed shows, by the present view, conceptual autobiographical knowledge being linked to sensory-perceptual episodic memory, and in so doing provides a retrieval context for EMs.

3. EPISODIC MEMORY

In our view EM refers to the ability to recall in considerable detail what occurred a few minutes ago and a few hours ago. Its temporal range may be defined by the individual's sleep/wake cycle and it may not extend beyond a sleep period during which, perhaps, some consolidation into AM occurs, as well as some forgetting. Because of its duration it is separate from conceptions of short-term memory (see Gathercole 1996, 1999) and working memory (Baddeley 1986). It is, however, closely related to a recent development in the working memory model that postulates a new temporary store termed the 'episodic buffer' (Baddeley 2000). The episodic buffer is a store in which knowledge from different areas of long-term memory and different modalities of input are bound into a memory representation and retained for a brief period of time (no more than a few minutes). One way in which to conceptualize EM is, then, as a type of memory that retains representations of states of the episodic buffer. According to the present approach, episodic memories

are short-duration summary representations of previous states of the working memory system and it is this conception that is considered in the following sections.

(a) *Functions*

One of the primary functions of EM is to keep track of progress on active goals as plans are executed. Because of this, episodic memory is especially attuned to changes in the goal states of the working self which, in turn, are marked by changes in the contents of consciousness. As attention turns from one activity, e.g. making a coffee, to another, e.g. writing a paper, so the currently active working self goals change. The central idea of this conception of EM is that when the goals change an EM is formed that links together states of the episodic buffer that occurred while those goals endured (cf. Newtson 1976). Outputs of the episodic buffer may be similar to what we have previously called 'event specific knowledge' and, when linked together into an EM, approximate to what Conway (1992) called 'phenomenological records'—records of recent states of consciousness. The purpose of the retention of such records over a period of minutes and hours is to provide highly specific information on recent plan execution, e.g. while drinking coffee recalling that the milk was returned to the fridge, or while writing recalling that a particular topic has been covered. This type of memory is a constant reminder of progress on current goals.

(b) *Knowledge*

EMs are highly detailed and retain knowledge of sensory-perceptual information abstracted from working memory, abstract knowledge (evaluations) relating to very specific goals (goals that download into actions without further subgoal processing), sensory-perceptual summaries, and even some literal records of states of the episodic buffer (ones that carry goal attainment information). By this view, then, EMs contain both abstract–conceptual and sensory-perceptual knowledge, with the latter dominating. Conceptual knowledge in an EM might function to organize sensory-perceptual details into coherent chunks of experience. For example, schema knowledge such as 'making a cup of coffee' might index or organize images of the kitchen, the fridge, the kettle, the mug tree, etc., as these were in a recent encounter as well as records of taking the milk out of the fridge, pouring the boiling water and other goal-relevant actions. Thus, EMs contain some abstract knowledge and substantial event-specific knowledge. They do not, however, contain general event knowledge or lifetime period knowledge and this is because they have yet to be integrated with knowledge structures in the autobiographical knowledge base. Instead, their context or index is 'today' or, possibly, 'yesterday' and they act as the database of the 'I' or experiencing self. However, even though their context is the 'I' they are in a form of 'goal-related-abstract-knowledge-plus-event-specific-knowledge' that can be readily incorporated into the autobiographical knowledge base (the 'me').

Yet despite the preparedness of EMs for integration with existing AM knowledge structures, it is unlikely that many are retained. Given the heavy storage cost of the large numbers of minutely detailed EMs generated in any one day, long-term retention is unfeasible. Instead, through rehearsal, or lack of it, and associated inhibition (see Conway *et al*. 2000) most EMs may be lost (permanently) within a short period. Retention critically depends on integration with existing structures in the knowledge base, which themselves may be changing and developing into stable AM knowledge structures. Because EMs are sensory and highly goal-specific, when accessed as event-specific in autobiographical remembering they have a special status in goal attainment appraisal. Even the mundane example of recalling a coffee break taken while writing a paper carries with it a great deal of goal-relevant information about how a past self dealt with a difficult and complex task. Recalling images and feelings gives rise to recollective experience which convinces the rememberer that the event in mind did in reality occur and, consequently, inferences about the past self are based on, or grounded in (memories of) actual actions.

(c) *Access*

Episodic memory, like AM, is undoubtedly highly cue-sensitive. External and internal cues in the immediate environment will map directly onto recently formed EMs and in this way reminding of the recent past will be potentiated and must frequently occur. Given this high degree of cue sensitivity, direct retrieval may be one of the main ways in which EMs are accessed. However, an important difference between EM and AM is that EM (as conceived here) does not support generative retrieval. This is because EMs are not organized in terms of an elaborate conceptual structure. Instead they are conceived as being represented in a rudimentary form of temporal organization, possibly according to actual order of experience (Conway 1992). This temporal form of organization supports a type of access not possible in AM, namely cue-independent access. Cue-independent access may involve a 'mental reaching back' into the very recent past. When retrieval takes this special form, EMs of the actions of a few minutes or hours ago 'pop' into mind. In fact, there is often a cue present in the cue-independent retrieval but it is a general one and does not correspond to EM content, e.g. 'What was I doing earlier?', 'What was I doing this morning?', or even the more general 'What was I doing?'. It is also noteworthy that the focus of retrieval here is very often on what the rememberer had previously been doing, or, in other words, on memories for goal-driven actions. EMs can then be accessed by cues that map onto memory content, i.e. by the process of encoding specificity (Tulving & Thomson 1973), or alternatively they can be accessed in a way that does not depend on memory content and which, therefore, is independent of encoding specificity. This alternative way in which to retrieve EMs involves a 'mental reaching back' which is unique to episodic remembering.

(d) *Phenomenology*

Brown & Kulik (1977) in their original paper on 'flash bulb' memories noted the 'live' quality of these long-lasting highly vivid memories. They observed that such memories often contained the very sort of event-specific sensory-perceptual details that are typically lost from memories of other less consequential experiences. These

details and the 'live' quality are, however, ubiquitous features of EM and, as a consequence, our recall of the very recent past is flash bulb-like in its clarity. All of which promotes the experience of recollection that is a characteristic, if not defining, feature of EM (Wheeler *et al*. 1997). Indeed, it is only when EMs become incorporated into an AM during memory construction that the past is recollectively experienced and a specific memory formed. Autobiographical knowledge can, however, be accessed independently of EMs and when this occurs recollective experience is absent and, instead, access is accompanied by feelings of knowing.

Another feature of the phenomenology of EMs is that they can also give rise to feelings of familiarity. That is they may trigger a feeling that some item has been recently encountered without leading to recollective recall of associated EMs. Presumably this occurs when memories are activated by a cue but the activation does not exceed a threshold leading to full memory formation. The 'feeling-of-familiarity-of-occurrence' is not the same as feelings of knowing encountered in autobiographical remembering and other types of access of long-term knowledge (cf. Conway *et al*. 1997). These latter knowing feelings are about feeling that what has been accessed is correct for a particular task or they are a type of recognition that what has been accessed is part of long-term knowledge, part of what a person knows. Thus, EM and AM are associated with different types of memory awareness. Episodic memory supports recollection and familiarity, whereas AM primarily supports feelings of knowing.

(e) *Neurology*

Many neuroimaging studies of human memory focus on recall of minutiae over short retention intervals and so, in effect, are studies of the type of sensory-perceptual EM considered here. Nyberg *et al*. (1996) in a meta-analysis identified several right hemisphere sites as critical in remembering minutiae from the very recent past (usually, but not always, recognition of individual words from a previously presented list). The convergent finding over many studies was that of activation of regions in the right prefrontal cortex (PFC), supporting the proposal of Tulving and colleagues (e.g. Tulving *et al*. 1994) that the right PFC was specialized for retrieval and the left for encoding. Subsequent meta-analyses have questioned this, and in their review Nolde *et al*. (1998) conclude that for simple memory tasks, such as recognition, typically only regions of the right PFC are activated, whereas for more complex memory tasks, such as cued and free recall, regions of both right and left PFC are active. The present perspective suggests that the more complex memory tasks are, the more they directly engage the goal structure of the working self—if only because they are more cognitively demanding—and left PFC activation may reflect this. In contrast, right side activation may reflect activation of networks that mediate EM. According to this reasoning the differences in laterality of activation across different memory tasks are related to the degree to which the working self becomes involved in accessing EMs (cf. Craik *et al*. 1998).

The emphasis on the role of the PFC in remembering very recent events has perhaps diverted attention from other regions that may also play an important role in episodic and autobiographical remembering. For instance, imagery is frequently present during remembering and so it might be expected that regions known to be involved in imagery (cf. Thompson & Kosslyn 2000) would become active in remembering—especially in episodic remembering where sensory perceptual knowledge of the past dominates. Regions of the occipital lobes, inferior and posterior temporal lobes have been found to be active in recognition of words (Gonsalves & Paller 2000) and in the recall of autobiographical memories (Conway *et al*. 2001*a*). Presumably these regions would be active in episodic remembering too and, indeed, Nyberg *et al*. (1996, fig. 2) present findings that this is the case. In many studies, however, activation in these regions may go undetected because it is subtracted out from control and contrast tasks, which themselves feature imagery. Interestingly, in Nyberg *et al*. (1996), Fink *et al*. (1996) and Conway *et al*. (2001*a*), strong activation of predominantly right temporal and occipital lobes was detected in both an episodic task (recognition of very recently studied materials) and in the recall of autobiographical memories, which is what might be expected if both involve the activation of sensory perceptual EMs.

Another region long known to be involved in the recall of recent memories, the hippocampus and associated structures, is also relatively rarely detected as selectively active in neuroimaging studies of EM and AM (for a recent study, see Conway *et al*. 1999). In contrast, neurological injury to this region invariably results in amnesia and other types of memory impairment. Especially interesting here is a report by Bancaud *et al*. (1994) who describe how epileptic seizures with a medial temporal lobe focus often result in a 'dreamy state' consisting of vivid memory-like hallucinations and intense feelings of *déjà vu*. Conway & Fthenaki (2000) argued that the feeling of 'pastness' that characterizes the *déjà vu* experience is similar to the feeling of pastness present in recollective experience. That is to say that *déjà vu* might be thought of as 'recollective experience for the present'. Bancaud *et al*. (1994) report the findings of a neuroimaging study, which included implantation of electrodes into various brain regions of epileptic patients with seizure foci in the temporal lobes. In this study they recorded the locus of activations occurring during the dreamy *déjà vu* state that preceded seizure onset and, also, the spread of activation. They concluded that a network distributed through medial and lateral temporal lobes mediated the experience of *déjà vu* and that the anterior hippocampus, amygdala and superior temporal gyrus had direct access to this circuit (activation of networks in these structures could spread to the medial–lateral temporal circuit and activate it). If, as we have suggested, *déjà vu* is a type of inappropriate recollective experience for the present then, possibly, the feeling of pastness present in recollection is mediated by networks in temporal and limbic sites.

Dysfunctions of recollective experience have not been extensively studied but the few studies that have examined impairments following brain damage (Curran *et al*. 1997; Levine *et al*. 1998) have found this to be associated with frontal pathology. In contrast, a recent patient we have been studying (A.K.P., Moulin *et al*. 2001) has

medial temporal pathology, more prominent on the left compared with the right, with atrophied hippocampi. Note that this is not degenerative and a diagnosis of probable dementia of the Alzheimer's type has not been made. Frontal pathology has not been detected in A.K.P., he presents as intellectually intact and competent and performs well on neuropsychological tests of frontal function. He does, however, confabulate and these confabulations are largely associated with (frequent) experiences of *déjà vécu* in which he has a strong feeling of having done what he has done before. For example, when given the morning newspaper by his wife he claims to have already read it. When this is questioned he confabulates a memory of having been to the newsagents earlier in the morning and read it then. When his wife found a coin in a public place he remembered putting it there for her to find. While on a walk he was amazed to observe the same bird on the same bough of the same tree that he had seen previously. Indeed so powerful is his experience of *déjà vu* that he watches far less television than he used to because he feels he has already seen most of the programmes; he also reads far fewer books again feeling that he has already read any title presented to him. In various memory tests featuring judgements of recollective experience he systematically over-extended recollective experience to new items which he incorrectly judged as old. There was also confabulation of some autobiographical memories as well as some accurate recall.

Presumably, the temporal and hippocampal damage has led to his chronic *déjà vu* and this lends further weight to the suggestion of a recollective experience circuit in these regions. Perhaps this is normally controlled by other (frontal) systems, such as the goal structure of the working self, that acts to suppress not only awareness of task-irrelevant knowledge but also recollective experience. A further notable aspect of A.K.P.'s pathology is the linkage between recollective experience (*déjà vu*) and confabulated memories. This may occur because recollective experience signals to a rememberer that what is in mind is a memory of an actual experience and not some other type of representation such as a fantasy or dream. As a result of his brain damage this signalling occurs inappropriately in A.K.P. where normally it would have been suppressed or prevented by frontal control systems. These or other control systems then confabulate an account in response to the experience of recollection. The confabulations function to justify or make consistent the recollective experience. This may be a non-conscious process as A.K.P. has little insight into his memory problems and he is strongly resistant to surrendering his confabulations when challenged. From the present perspective with its focus on goals and memory it is particularly relevant that A.K.P., because of feelings of remembering, no longer undertakes certain goal-related habitual activities.

4. SENSORY-PERCEPTUAL EPISODIC MEMORY

This view of sensory-perceptual episodic memory categorizes EMs as unusual mental representations in that they are conceived as small 'packets' of experience derived from conscious states that remain intimately connected to consciousness by instigating recollective experience during remembering. It is their 'near-experience' quality that sets them apart from other types of knowledge and other, more conceptual, representations of the past (such as AM). In the present conception EMs provide a link from working memory to long-term memory and in so doing suggest ways in which momentary experience might be retained and later incorporated into consciously formed memories.

The author thanks Alan Baddeley, John Gardiner and Sue Gathercole for insightful comments on an earlier version of this paper and also Kit Pleydell-Pearce, Sharon Whitecross, & Helen Sharp for figure 1 and EEG data. Writing was supported by the Department of Experimental Psychology, University of Bristol, England, and by the Biotechnology and Biological Sciences Research Council, grant 7/S10578.

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